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Thick-film Heavy-metal Sensor of Chalcogenide Glass

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Abstract:
This paper reports on the development and verification of a potentiometric sensor based on chalcogenide glass of novel composition to determine copper ions in aqueous solutions. The sensor is assembled by way of thick-film technology on a ceramic substrate.

Key words: Heavy metal ion sensor, determination of heavy metals, potentiometric sensor, chalcogenide glass, thick-film technology, copper, lead.

Introduction

Sensors and the measuring technology in its context are indispensable for our present-day life. Heavy metals may get into the environment via industrial waste water and exhaust gases, for example, and may harm humans and the environment due to their toxic properties. Hence, there is an urgent need for heavy-metal detection in environmental analytics as well as for the surveillance of industrial processes. Especially in water analysis, ion selective electrodes (ISE) have stood the test, as they are reasonable in price, simple to handle and capable of being used in “on-site” analytics [1].

Investigations

One focus of the work consists in developing and verifying novel ion-sensitive chalcogenide glass in a tube furnace [2,3] and in characterizing it by way of scanning electron microscopy (REM-EDX), X-ray diffractometry (XRD), differential thermal analysis (DTA), thermogravimetry (TGA), dilatometry and atomic absorption spectroscopy (AAS) to qualitatively and quantitatively determine the composition of the amorphous materials (Fig. 1).

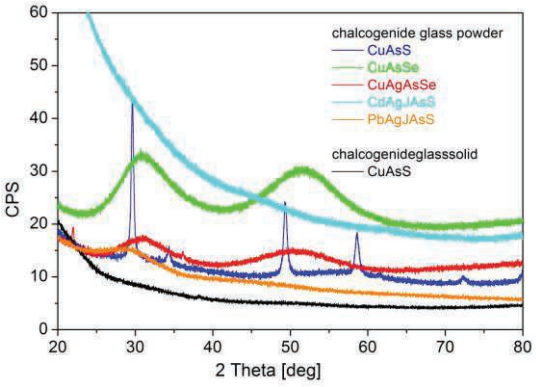

Fig. 1. X-ray diffraction diagrams of Cu^{2+} and Pb^{2+} sensitive solid chalcogenide glass.

Preliminarily, rod-like potentiometric chalcogenide-glass sensors were manufactured, followed by assembling thick-film electrodes by applying glass paste onto a planar ceramic substrate in order to test their electrochemical properties regarding their electrode functionality (Fig. 2), transverse sensibility, response behavior and long-term stability.

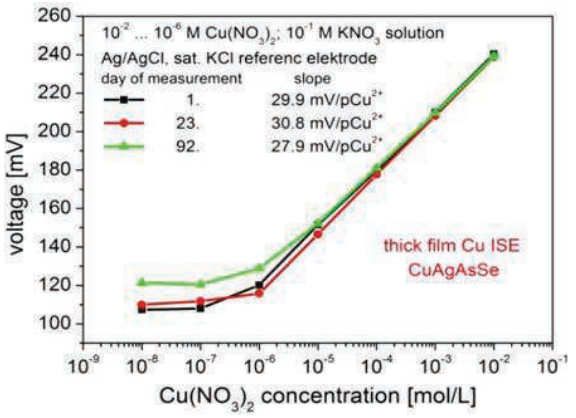

Fig. 2. Calibration curve of a copper electrode in thick-film technology

Sensors

The sensor layout of a multisensor manufactured in thick-film technology to determine the pH value, the redox potential, the temperature and the Cu^{2+}-ion concentration is shown in the microscopic image of Figure 3 in fourfold enlargement. The multisensor is 15 mm long and 6 mm wide. On the underside, there is a Ag/AgCl reference electrode and a Pt1000 temperature-measuring sensor.

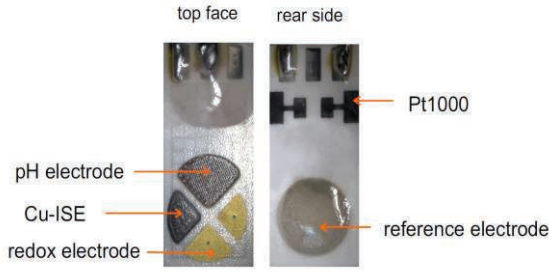

Fig. 3: Multisensor (enlarged fourfold)

Summary

Novel ion-sensitive chalcogenide glass was smelted and characterized for manufacturing a reasonably priced, mechanically robust and miniaturized thick-film-based Cu^{2+}-heavy-metal ion sensor and, after assembly, tested by rod-like and thick-film measuring electrodes.

In addition to that, multisensors were produced. The sensor arrays can be used to determine the pH value, the redox potential, the temperature and the copper-ion concentration in solutions.

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